

## Executive Summary

### Background:

Researchers, policy makers and community advocates have been interested in developing a screening method that can identify areas of special concern for the cumulative impacts of environmental and non-environmental stressors in California. Because of previous studies that have shown a pattern of racial and income disparities in air pollution exposures and health risks in the state (Sadd, Pastor et al. 1999; Morello-Frosch, Pastor et al. 2002; Pastor, Sadd et al. 2004; Su, Morello-Frosch et al. 2009), such a method could be useful in implementing environmental justice mandates and could also advance the emerging field of research about the intersection of potential cumulative hazard exposure and social vulnerability.

### Methods:

To work toward developing such a screening method, this effort consisted of a set of interlocking and interdependent research efforts, including:

- 1) A baseline analysis of environmental justice conditions in one part of the state not previously the subject of systematic spatial analysis and multivariate statistical modeling, with an eye toward identifying key determinants associated with patterns of racial and ethnic disparities in lifetime cancer risk and respiratory hazard associated with outdoor air toxics exposure. Innovative spatial techniques were used to associate tract-level demographics with facility locations and spatial autocorrelation controls were used and compared with simple ordinary least square (OLS) strategies. Community members were involved in reviewing the early research as part of the PIs' commitment to incorporating community feedback on the research as it evolved.
- 2) An analysis of the association between ambient criteria air pollution and adverse perinatal outcomes, utilizing multi-level analysis to assess both individual-level SES variables and neighborhood-level SES variables simultaneously and examining whether they may potentially modify observed associations between air pollution exposures and adverse birth outcomes. We specifically investigate effects for full gestational exposures as well as trimester-specific effects using data collected from air pollution monitors for particulates (PM<sub>2.5</sub>, PM<sub>10</sub> and coarse PM) as well as CO, NO<sub>2</sub>, SO<sub>2</sub> and ozone.
- 3) The development of an Environmental Justice Screening Method (EJSM) utilizing measures of hazard proximity and sensitive land uses, cumulative impact from potential air pollution exposures and estimated cancer and respiratory risks, and indicators of social vulnerability, all at the census tract level, to calculate relative scores for high priority areas. Innovations in the process included the creation of a land use layer for Southern California that focuses on land uses identified as sensitive according to ARB guidelines (CARB 2005), the intersection of this layer with block-level demographics data to drive attention to the finest geographic unit possible, and the creation of a simple distance-decay and population-weighting procedure that generates a tract-level score on hazard location that can then be combined with simple quintile rankings on air pollution

hazards and social vulnerability measures. One specific driver in the process was a requirement that we develop a method that was transparent and accessible to a diverse audience, including regulatory decision-makers and communities. As a result, the EJSM was periodically reviewed throughout its development and evolution by scientific colleagues from an external peer review committee as well as community advocates throughout the state.

- 4) The use of the EJSM to evaluate the environmental justice dimensions of the hypothetical siting of a power plant and the comparison of those results with the approach to environmental justice screening usually applied by the California Energy Commission (CEC) in a siting process. We specifically chose the Nueva Azalea plant, a project that was proposed for South Gate, California but was never sited due to community concerns that eventually led the company to withdraw its application for the site. To conduct this analysis, we scored the locations of all existing power plants using our EJSM in order to determine a range of feasible sites.
- 5) The development and implementation, in conjunction with community-based partners, of a “ground truthing” microstudy in the Hegenberger Corridor of Oakland. The project consisted of conducting a local-scale validation study to identify and locate emissions sources that may not be systematically incorporated in state regulatory agency data inventories and measurements of community-level air pollution burdens; the PIs worked with a community organization to train local residents in the ground truthing protocols, and they eventually worked together to conduct some pilot particulate air monitoring as well. Aside from augmenting and validating information from ARB emissions inventories regarding the existence and location of area and point emission sources and sensitive land uses, this project also provided a way to strengthen community engagement in the research and regulatory process related to local air quality and environmental health concerns.

## Results:

Each of the interlocking parts of the project produced their own separate but also interacting results that informed each other. For example, the Bay Area EJ analysis and the birth outcomes study helped inform the screening method; the screening method was essential to the siting simulation, and the “ground truthing” exercise (along with community input in devising the Bay Area analysis and reviewing early versions of the screening method) helped to build community credibility for the broad project goal of advancing EJ Methods in ways that better inform regulatory decision-making. The results were as follows:

- 1) The Bay Area environmental justice analysis indicated that environmental justice disparities were indeed a concern in terms of both community proximity to emission facilities with active air releases as recorded in the Toxic Release Inventory as well as estimated cancer risks and respiratory hazards associated with ambient air toxics. Disparities for African Americans and Latinos persisted in a multivariate regression analysis, controls for spatial autocorrelation tended to slightly attenuate effect estimates but not eliminate their statistical significance, and the degree of linguistic isolation

(measured as the share of households in which no member 14 years old and above speaks English only or English “very well”) was a significant explanatory factor in most model specifications. These findings demonstrate that social disparities are persistent even after controlling for potential confounding, and this study also helped elucidate some new important variables, particularly linguistic isolation, as factors to consider in an EJSJ incorporating social vulnerability.

- 2) With regard to birth outcomes, our study builds upon existing work by analyzing the effect of air pollution on birth weight and preterm birth in California. We used California and federal monitoring data for PM<sub>2.5</sub>, PM<sub>10</sub>, CO, NO<sub>2</sub>, SO<sub>2</sub>, and ozone to assess the relationship between ambient air pollution exposures and birth weight among infants born between 37-44 weeks gestation during the years 1996-2006. We also examined air pollution effects on the risk of preterm birth. We estimated ambient exposures to coarse PM, where coarse particle exposure was defined as the difference in ambient exposures for respirable and fine particles (PM<sub>10</sub> - PM<sub>2.5</sub>). We assessed the consistency of our effect estimates by testing our models using different nearest monitor radii distance limits for the births we examined from air monitors. Consistent with prior literature, we have shown a modest inverse relationship between ambient criteria air pollutant exposure (PM<sub>2.5</sub>, PM<sub>10</sub>, coarse PM, CO, NO<sub>2</sub> and O<sub>3</sub>) and birth weight among full-term infants as well as risk of preterm birth. Overall, these associations between increasing pollutant exposures and decrements in birth weight and risk of preterm delivery persisted during different trimesters of exposure, although the strongest effects were seen for exposures during the entire gestational period. The results were generally robust in co-pollutant models and across different radii distance limits from air monitors. The results, along with the disparity findings in the Bay Area analysis, suggest reasons why a screening method might be useful for policy makers concerned about environmental health and justice.
- 3) We developed an EJSJ that incorporates multiple indicators of cumulative impacts, including: ambient criteria air pollution exposure, cancer and respiratory hazards associated with modeled air toxics estimates, social vulnerability, and a proximity score (based on a simple distance decay function and population weighting to the tract level). The last of these, the proximity score, provides an indicator of land use (hazard and sensitive land use) which have been identified as important policy and regulatory issues for diverse stakeholders. Because proximity metrics alone do not provide information on potential pollutant exposures or possible human health risks, we also integrated a second dimension of cumulative impact based on air-related measures of potential health risk, including ambient criteria air pollution exposure and cancer and respiratory hazards associated with modeled air toxics estimates. Finally, we also incorporated a third dimension that is based on a range of social vulnerability indicators. These are brought together to create a cumulative score that could identify communities of environmental justice concern. The EJSJ is transparent (partly because it relies on intuitive scoring strategies like quintile rankings), and it is adaptable by the agency and sophisticated outside users (as it consists of a few documented Geographic Information Systems (GIS) routines, coupled with a programming exercise); the latter means that agency and other users can weight or add different metrics of cumulative impact and add or update data as

necessary. The method is currently limited to Southern California because of the land use data requirements for our proximity measures but could be adapted to other locations with lower-quality but still usable land use data. Trainings in the EJSM were conducted with the ARB staff during Spring of 2009, and we have transmitted the relevant data layers and programming syntax. Community advocates were engaged in previewing and reviewing the EJSM to enhance its transparency and ensure its credibility as a tool to guide regulatory decision-making on EJ issues.

- 4) The EJSM was used to evaluate the hypothetical siting of the Nueva Azalea plant. We demonstrated that the usual screening procedures of the CEC would likely have rated this site as no worse than many others in terms of EJ issues; the EJSM suggests that the site was one of the “worst” possible areas if one concern was to ameliorate the current pattern of environmental disparity in plant siting. We note that only one plant ranks higher on the environmental justice screening score and that plant has been the subject of major protests concerning its expansion. We conclude that the screening method may have particular strength in predicting likely community reactions, partly because it contextualizes any particular site within a broader landscape of hazard proximity, air pollution burden and social vulnerability.
- 5) The Hegenberger Corridor microstudy encouraged positive community engagement and enhanced understanding of the research and regulatory process related to local air quality concerns. The study also leveraged community knowledge of local environmental hazards and sensitive receptors to highlight opportunities that would better reduce emissions and protect community environmental health. Most importantly, ground truthing efforts enabled the community to verify the extent to which official emission inventories adequately capture the location and number of emission sources and sensitive receptors, and it can be a way for ARB to periodically evaluate the extent to which data sources are adequately capturing the potential cumulative impacts of multiple emission sources in EJ communities. A small particulate pilot air monitoring study also suggests that there may be local emissions sources of regulatory concern.

#### Conclusions and Recommendations:

This project entailed multiple components that received ongoing external review and feedback from scientific colleagues and community advocates, particularly for the EJSM, because of its critical application to regulatory decision-making, as state policy mandates that attention be paid to environmental justice issues in the implementation of air quality regulation and, more recently, climate change mitigation strategies as required by AB 32, California’s Global Warming Solutions Act .

Going forward, the results of this project highlight several future research and policy opportunities. First, metrics of social vulnerability must be central to the development of scientifically valid methods for assessing geographic disparities in the potential cumulative impacts of pollution burdens across diverse communities in the state. In addition to metrics of SES (such as race/ethnicity, poverty, employment status, etc.), new metrics of community capacity for civic engagement, such as linguistic isolation, are significant and suggest the need

for targeted outreach to better engage language-minority populations in the regulatory process. Second, we think our project's confirmation of the adverse impacts of air pollution on birth outcomes raises the need to consider perinatal health outcomes in future regulatory decision-making regarding criteria air pollutants. Third, we think that the successful integration of community advocates into several aspects of this work – including the Bay Area EJ analysis, the EJSM development, and the Hegenberger microstudy – highlights how combining scientific peer review with ongoing community feedback can ensure that methods development is both scientifically valid and transparent, and that project results are disseminated in ways that productively connect to current environmental justice policy and regulatory concerns.

As for the EJSM, future work should involve developing the land use data (or land use proxy measures) necessary to implement it on a statewide level. Additional metrics and data layers can be integrated into the EJSM to better tailor the tool to specific policy issues. For example, the incorporation of traffic density metrics would be important to build into the screen (given both the social disparity in pollution burdens from mobile sources shown in the Bay Area analysis and the adverse impacts of pollution, much of which comes from mobile emissions, on birth outcomes).<sup>1</sup> Additional data layers should be considered by consulting with scientific colleagues working on environmental and public health tracking initiatives within California and nationally. Finally, alterations to the EJSM, particularly with regard to reweighting data layers or imposing more complicated scoring methods (such as standard deviation breaks or z-scores,) should be weighed against the complexity of implementation and the need to balance scientific validity with transparency in cumulative impacts assessment efforts that are aimed at informing regulatory decision-making.

---

<sup>1</sup> Including traffic metrics was suggested in the original research proposal but not included in the funding after scoping discussions prioritized other aspects of the project; we are in the process of adding a traffic exposure metric to the EJSM as part of a research contract funded by US EPA Region IX but such incorporation was not part of the deliverables for this effort.